Contribution to IEEE802.3bt, CP2PRUNB ad-hoc.

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From which total PD load current the CP2PRUNB requirements are not required to be met?

To answer this question, we need to go first back and understand why we care about Channel Pair To Pair Channel Resistance Unbalance (CP2PRUNB)?.

List of facts:

1. In IEEE802.3-2012 the pair current was 600mA max DC, at normal operation condition. This was for Type 2 systems i.e. 2P systems.

2. As a result of this specifications, Channel components such magnetic components, connectors and others were specified, tested and approved to be working with this current levels (600mA). ***Why this fact is important to our subject title above? What is the magic of this number? What are the "scientific" foundations of this number? ALL will be clear when we discuss Type 3 systems below.***

3. Now we are in IEEE802.3bt and we want to allow 4P operation.

There is a wide consensus that we will have two types of 4P systems for optimizing cost per market needs.

3.1 Type 3: Twice the total power/current of Type 2.
3.2 Type 4: Greater than twice the total power/current of Type 2 and less than 100W

For addressing the above subject question, let's start with Type 3 systems first.
For Type 3, the system vendors would like to use the same components that were used in Type 2 system. Why? Because we are talking about the same current per pair, 600mA so there is very good chances that we can reuse this components. Now, here comes the importance of CP2PRUNB and its effect.

Due to the CP2PRUB the total load current between all 4 pairs is split not evenly.
-So if the total load current is It:
-The current unbalance between pair_i (=I1) and pair_j (I2) is Iunb=I1-I2=ΔI
-Iunb=I1-I2=P2PCRUNB*It=ΔI
-CP2PRUNB[%]=100%(∑Rmax-∑Rmin)/(∑Rmax+∑Rmin)=26.2% per our worst case analysis at room temperature.

As a result, you will see that:
I1=It/2 + ΔI/2
I2=It/2 – ΔI/2
If you sum up I1+I2 we will get It value again, and you can also figure out what is ΔI/2 value.

So when CP2PRUNB requirements are relevant?

No we can answer this question:

We saw that:

I1=It/2 + ΔI/2. Here due to CP2PRUB, I1>It/2=600mA by ΔI/2= P2PCRUNB*It/2. This may affect magnetic that was designed to 600mA. *(We will see that in more detailed discussion in next meeting the effect is small but it is there. So in order to keep the discussion technically accurate, I will not neglect the effects that we are aware off).*

I2=It/2 – ΔI/2. Here the current is less than 600mA so no effects on Type 3 components that naturally uses Type 2 components.

As a result:

1. For Type 3 systems (and even more for Type 4 systems) CP2PRUNB is relevant when PD load power/current is at a level that causes pair current to be > It/2 which is the 600mA…..!!!. This may require using different magnetics design that can handle OCL at >600mA and up to at least 600mA+ P2PCRUNB*It/2.
   (I am ignoring operating current up to Icut per IEEE802.3-2012 that is required anyway for simplifying the discussion. Otherwise you need to multiply this number by ~1.15 and this is magnetic component spec issue.)

2. So it became obvious that that CP2PRUNB requirements for Type 3 systems are irrelevant if PD total load current, It_max is:
   It_max=I1_max+I2_max=
   (600mA+ P2PCRUNB*It/2 - P2PCRUNB*It/2) +
   (600mA- P2PCRUNB*It/2 - P2PCRUNB*It/2)=
   1.2A - P2PCRUNB*It.

- It_max=1.2A - P2PCRUNB*It. (The decision break point of Type 3 systems)
- If It>Itmax, CP2PRUNB requirements shall be met for Type 3 and up systems.
- If It<Itmax for Type 3 system, CP2PRUNB requirements are not required to be met.

Note: *We will see later in next discussions that the fact that we are using constant power sink load will works for us in a way that the absolute value of It, will be the lowest when we have the worst case CP2PRUNB which happens at short cable.*
As a result we will have to check the It_max as function of constant PD load sink ie. Itmax=It/2+ P2PCRUNB*It/2.

$$It = \frac{Vpse + \sqrt{(Vpse^2 - 4 \cdot R \cdot Ppd)}}{2R}$$, which is a function of channel length represented by R which is the total channel pair equivalent resistance. We can see that 1.2A is just a maximum number for Type 3 (2x0.6A=1.2A) at 100m channel length but the actual value of the total current where CP2PRUNB is maximum, Is much less than 1.2A. At zero cable length it will be Ppd/Vpse=51Wmax/50V=1.02A and not 1.2A. it leaves 180mA margin for Type 3 total maximum current that will reduce the increase of pair current due to CP2PRUNB.

Now we can answer question and responses received during our 3rd meeting on April 24, 2014.
Please see below Q&A. (Changes from last discussion are marked with blue and RED)

(1) Yair Proposal (modified to accurately reflect the above analysis and last discussions)
For Type 3 PD, were PD total power is below TBD Watts that ensures total PD current below It_max=(1.2A - P2PCRUNB*It), meeting PD PI Pair to Pair Resistance Unbalance is not required.
(Note, "It" will be replaced later by the system It current equation and parameters that reflect constant PD power sink load.)

(2) Christian Biea proposal
For PD total power below 25.5 Watts (that ensures pair current <600mA/pair), for any pair, meeting PD PI Pair to Pair Resistance Unbalance is not required

Yair response: This is surely OK but is not utilizing our full capacity to make the spec simpler and allow more power at the Type 3 PD ~~for Type 3 systems~~ that doesn't require special new designs and still use Type 2 components for Type 3 systems without the need to meet CP2PRUNB therefore I believe option 1 is better for us.

Jeff Heath: What is the magic in the 6000mA number? Why we don't have scientific proof that 600mA is the number.

Yair: See above analysis. The main point is to allow for Type 3 systems to use Type 2 components. Therefore the 600mA is max/pair is the number to start with. Now I have supplied even more accurate number addressing total maximum PD load current as function of CP2PRUNB per Christian comment.

Jeff Heath: Why we the 600mA if cable adhoc discussing >600mA per pair.

Yair response:

1. See analysis above.
2. Cable ad-hoc discussing >600mA pair current for Type 4 system. It is irrelevant to Type 3 systems that is based on 600mA/pair so we can be compatible to Type 2 systems as well and re-use type 2 components at Type 3 systems.